

Raphanus raphanistrum L. (Brassicaceae)
Wild Radish, Jointed Charlock

Description. Annual or biennial, herbaceous, from a taproot; stems 15-150 cm tall, erect, branched with spreading to appressed trichomes, becoming glabrous. Basal leaves 6-20 cm long, oblanceolate, deeply and pinnately lobed; cauline leaves alternate, usually reduced and entire or lobed, petiolate. Flowers in flat-topped inflorescences; pedicels in fruit 10-25(50) mm long, sepals 5-10 mm long, petals 15-20 mm long, pale yellow, often fading to white, sometimes tinged or veined with violet or purple. Fruit a silique, 40-80 mm long, 3-6 mm wide, with a sterile beak 10-20 mm long, the silique glabrous to pubescent, strongly constricted between the seeds, breaking apart into 1-seeded segments. Seeds 1.5-4 mm wide, subglobose, surface usually reticulate, 4-12 per silique. (Barker 1986, Chater 1964, Clapham et al. 1962, Fernald 1950, Munz 1959, Rollins 1993).

The closely related species, *R. sativus* L. (radish), differs by having purplish petals, fruits weakly constricted (if at all) between the seeds, and with only 1-5 seeds per fruit. Hybridization between the two species is well documented and has resulted in widespread introgression, especially in California and Europe (Conner et al. 1997, Lee and Snow 1998, Lefol et al. 1997, Panetsos and Baker 1967).

Geographic distribution. Wild radish is a native of Mediterranean Europe, but widely naturalized throughout northern Europe, western Asia, Australia, New Zealand, Africa, North and South America, and India (Arnold and de Wet 1993, Chater 1964, Clapham et al. 1962, Diaz Losada et al. 1996, Fernald 1950, Garrido and Dhingra 1997, Barker 1986, Hewson 1982, Sharma and Dhaliwal 1997, Webb et al. 1988, Webb et al. 1988, Zakeri and Banihashemi 1996).

Both *Raphanus raphanistrum* and *R. sativus* were first reported from several areas in California in the 1870s (Bolander 1870, Brewer et al. 1876). *Raphanus sativus* was first collected in 1840-1841 near Fort Ross (Baker 1974, Howell 1937).

Naturalized populations occur on Santa Cruz and Santa Rosa islands (Junak et al. 1995), coastal California from Del Norte County southward to San Diego County, and in most counties of the Central Valley (Anonymous 1998, Rollins 1993).

Ecological distribution. In both natural and naturalized geographic ranges, *Raphanus raphanistrum* and *R. sativus* occur in fallow fields, waste areas, and disturbed areas along roadsides. *Raphanus sativus* is particularly well adapted to croplands that experience regular cultivation. (Baker 1974, Lorenzi and Jeffery 1987, Munz 1959, Robbins et al. 1970, Rollins 1993).

Reproductive and vegetative biology. Both species of *Raphanus* are bisexual and self-incompatible, and are consequently open-pollinated, principally by bees, syrphid flies, and butterflies (Cabin et al. 1996, Conner 1997, Conner et al. 1995, Conner and Rush 1996, Kay 1976, Kercher and Conner 1996, Stanton 1987, Stanton et al. 1986, 1989). Fruit set is pollen-limited in *Raphanus raphanistrum*, suggesting that insect visitation appears to be critical to pollination and fertilization (Pfenning and Conner 1997).

Viability, germinability, and success at establishments is dependent on seed size and seed nutrient reserves in both *Raphanus raphanistrum* and *Raphanus sativus* (Choe et al. 1988). Seeds do not appear to have a significant dormancy, require moist soils that are exposed to light, and germinate within a short period of time (White and Harper 1970). In Mediterranean and temperate continental climates, wild radish seeds germinate in the late winter or spring respectively, developing vegetatively during the winter or spring, and begin flowering in late spring or early summer (Conner et al. 1996a, 1996b). Rates of germination, at least in *Raphanus sativus*, are related to depth of planting; seeds closer to the soil surface are more likely to survive than those at depths greater than 1-2 cm (Hewston 1964) or those in fine-textured soils (White 1968). Panetta et al. (1988) also reported varying patterns of germination and recruitment related to seed depth in crop fields. Mazer (1987) found that wild radish populations display variability in life history traits (including seed size) and that some fitness components (e.g., seed number, size, etc.) were heritable. *Raphanus sativus*, when grown as a crop plant in southern Africa, is not affected by competition with weedy allelopathic species (Reinhardt et al. 1994).

Weed status. Neither species (*R. raphanistrum*, *R. sativus*) are considered noxious weeds in agricultural or horticultural practice, at least at a global level (not listed by Holm et al. 1977), nor are they considered noxious weeds by the State Dept. of Food and Agriculture (Anonymous 1996). However, *Raphanus raphanistrum* has been considered an important weed in Australia (Donaldson 1986, Lemerle et al. 1996). Holm et al. (1977) note that it has been considered a serious weed in wheat-growing regions. In Spain, it is considered an important weed of certain crops (Gaspar et al. 1996). NOTE: In some parts of the world, including California, Japan, and Korea, daikon (*Raphanus raphanistrum* var. *sativus*) is cultivated extensively as a food crop (Huh and Huh 1995, Koike and Molinar 1997).

Microbial pathogens. Several species of fungi are known to infest both *Raphanus raphanistrum* and *R. sativus*, including *Phoma* (Chen and Seguin-Swartz 1997), *Verticillium dahliae* (Harada et al. 1997), *Myrothecium verrucaria* (Walker and Tilley 1997), *Alternaria brassicae* (Koike, Molinar 1997), and *Pseudomonas* (Norman et al. 1994). Inoculation of *Raphanus sativus* with *Myrothecium* reduced vegetative and floral biomass by as much as 50% (Walker and Tilley 1997). Simultaneous infection by *Peronospora parasitica* and *Albugo candida* have caused significant mortality in *Raphanus sativus* cultivated in India (Achar 1993).

In contrast, *Raphanus sativus* can serve as an unaffected host for several fungi (e.g., *Alternaria* spp., *Fusarium* spp.) that are deleterious to some crop plants (Tohyama and Tsuda 1995, Zakeri and Banihashemi 1996). Terras et al (1995) recently found anti-fungal proteins in the seed coat and leaves of *Raphanus sativus*, and which act as natural fungicides.

Nematode and insect pathogens. Both species of wild radish are susceptible to infestation or herbivory by larvae of the cabbage butterfly, *Pieris rapae*, which as an adult also represents an important pollinator in native habitats (Kay 1976, Lehtila and Strauss 1997). Ameen and Story (1997) observed that, under experimental conditions, the yellowmargined leaf beetle (*Microtheca ochroloma*) lived longer on wild radish than other potential hosts. Gardner and Caswell-Chen (1994) found *Raphanus sativus* to be susceptible to infestation by 3 different nematodes (*Meloidogyne incognita*, *Meloidogyne javanica*, and *Plasmodiophora brassicae*). Velasco and

Walter et al. (1992) and Panizzi and Saraiva (1993) reported that wild radish served as the principal host plant of the polyphagous stink bug (*Nezara viridula*), a pest in soybean fields. Buntin and Beshear (1995) reported damage by thrips (Thysanoptera), which significantly affected reproductive effort in wild radish under cultivated conditions.

Herbicide control. Because *Raphanus raphanistrum* is generally considered a pest only in grainfields, the use of 2,4-D has been recommended when crop plants are young (Lorenzi and Jeffery 1987). Soil sterilization using paraquat or high concentrations of 2,4-D has been recommended for local infestations in waste areas (Lorenzi and Jeffery 1987). Rimsulfuron has been found effective against wild radish in potato fields (Ivany 1996). Bedmar (1995, 1996) evaluated the usefulness of pre-emergents (flupoxam and prometryn) in control of radish in both sunflower and corn crops. Both pre-emergent (alachlor, thiobencarb) and post-emergent (glyphosate) herbicides have been used to control weeds in radish crops (Nandal and Arya 1995). They found that 1-2 kg per hectare did not affect growth rates or seed production. Aliotta et al. (1993) reported significant inhibition of seed germination and radicle growth when seeds of *Raphanus sativus* were treated with coumarin and phenylpropanoids. Didon and Olsson (1997) obtained varying results when testing seed germination in the presence of two herbicides, dichlorprop and MCPA. Varying combinations of metribuzin, dicamba, 2,4-D, bromoxynil, and thiameturon were used to successfully control wild radish in wheat fields (Schroeder 1989).

Other control measures. Frequency and depth of cultivation may reduce recruitment of wild radish in certain crop fields (Cheam 1986).

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